brief accounts of later work. However, for the greater part of these two volumes, the article Bewegung der Hydrosphäre in Vol. VI., 1, 6, of the "Encyklopädie der mathematischen Wissenschaften," by Darwin and Hough, will be found to supply these needs. This article is to be reproduced, it is to be hoped in English, in Volume IV. of the "Scientific Papers."

I may mention one point in conclusion in connection with Sir George Darwin's presentation of his work which earns the gratitude of those who are unable from want of time or training to read his papers in detail as well as of those who do such reading but wish to get a general view of his processes and results as a first step. In the summaries to the longer memoirs he gives not only the general conclusions at which he has arrived, but also a brief account, without symbols, of the hypotheses on which the arguments are based, the methods employed and the general course of the mathematical procedure. These summaries have made the task of following his work very much less difficult and have doubtless contributed in some measure to the early acceptance of the theories which he has set forth.

The printing done by the Cambridge University Press is too well known to need comment here. The size of the volume adopted is the modern compromise between convenience for the printing of long formulæ and suitability of size for easy handling and reading, namely, the royal octavo between one and two inches thick.

ERNEST W. BROWN

The Problem of Age, Growth and Death: A Study of Cytomorphosis based on Lectures at the Lowell Institute, March, 1907. By CHARLES SEDGWICK MINOT. New York and London, G. P. Putnam's Sons. 1908. Pp. 280; good index.

Many biologists, and with them a wide circle of people who are intelligently interested in fundamental problems of life, have followed Professor Minot's researches in this field with keen interest for thirty years past, and will be glad to have the many scattered papers collected in book form and brought down to date. The purpose of the book is stated in the elaborate "introductory letter," which is addressed to Senator Mosso, to whom the work is inscribed. It is a study of "increase in the amount of protoplasm" as compared with the bulk of nucleus in the cells of the growing animal.

The first lecture deals with the process of growing old as seen in the body as a whole; and while the familiar data are exceptionally well presented, it calls for no special review. The second lecture, "Cytomorphosis—the Cellular Changes of Age," carries a somewhat parallel line of thought through the microscopical changes in the cells and tissues from the germinal to the senescent condition. Here we learn, in connection with appropriate figures in the text, about the "cytomorphic cycles" of different cells, connective tissue, nerve, muscle, gland and blood; and of the death and old age of cells in atrophy or degenerations of various kinds. As cells differentiate from the germinal to the adult form they become fitted to perform specialized functions, but lose the germinal power of growth and regeneration. Thus death is continually present in life, and may be even more active in the embryo, as, in the rapid whirl of cell-life, whole organs form and vanish, than during any other period of life. In fact one of the main theses is that: "The period of most rapid decline is youth; the period of slowest decline is old age."

The third lecture—"The Rate of Growth," gives the results of the author's extensive studies on the growth of guinea-pigs, rabbits and fowls and correlates them with those of Quetelet, Donaldson, Muhlmann and Thoma for man. The facts are presented with great precision in text, table, series of figures of embryos and by most striking charts and curves, growth being expressed, in the main, in percentage increments. The chief result is that power to grow is greatest in the germ and decreases rapidly with age. For example, using Richard Hertwig's calculation, the fertilized human ovum is 0.004 of a cubic millimeter; the child at birth from 3 to 4,000,000 cubic millimeters, which shows an increase of one billion times the original mass during gestation. From birth on to twenty years of

age the increase is only as 1 to 16. Thus Dr. Minot figures that: "Over 98 per cent. of the original growth power of the rabbit or chick has been lost at the time of birth or hatching," respectively, and the same thing is equally true of man. "We start out at birth certainly with less than two per cent. of the original growth power with which we are endowed."

While this conclusion is announced as most remarkable, and possibly it may seem so from the standpoint of an anatomist, the physiologist, and it would seem the biologist as well, would welcome it as a sign of efficiency. The quicker the machine can be built, adjusted and set to do the work designed for it the better. So the illustration which Dr. Minot chooses seems inapt. He says:

> But as that accumulation (of protoplasm) goes on, our body seems to become, as it were, tired. We may compare it to a man building a wall. He begins at first with great energy, full of vigor; the wall goes up rapidly; and as the labor continues fatigue comes into play. Moreover, the wall grows higher, and it takes more effort and time to carry the material up to its top, and to continue to raise its height, and so, as the wall grows higher and higher, it grows more slowly, and ever more slowly, because the obstacles to be overcome have increased with the very height of the wall itself. So it seems with the increase of the organism; with the increase of our development, the obstacles to our growth increase.

This statement of the case seems to be crucial to Dr. Minot's conception of the significance of growth and a biologist may be pardoned for wondering whether, even with so inapt a figure, the builder might not finish his wall and then use it, without fatigue; or whether, at certain stages in the work, he might stop building and begin chiseling inscriptions or ornaments upon it without fatigue. In reality we have, instead of a man building a wall of no definite height and for no definite use, an inventor building a machine, every dimension of which is fixed and subordinated to a definite purpose. It would be suicidal to go on "growing," building the machine larger after it is completed, and it is entirely conceivable biologically that the inventor might finish his machine and run it until it wears out or breaks down without any of the slowing down or growing tired of which our author makes so much. The wall simile must recall to the reader, the building of a certain tower, the completion of which was interdicted.

Special function presupposes specialized protoplasm, and we are next led to consider "Differentiation and Rejuvenation." The chief point in this field is that "*Rejuvenation is accomplished chiefly by the segmentation of the ovum.*" That is, in segmentation the cells are greatly diminished in size, with great increase in the amount of nucleus in proportion to protoplasm; and thus segmentation brings about the production of young cells.

The entomorphic cycle is thus again started, and as the cells differentiate and grow old it becomes impossible for them to become young again. The evidence is marshaled to prove that there is no "retrogressive development—Entdifferenzirung," as Driesch and Korschelt maintain. Instead of this certain cells retain the embryonic condition in all organs and tissues capable of regeneration and all such new growth is accomplished by proliferation of these young cells. Furthermore, the reproductive cells are early shunted out of the cytomorphic cycle of the individual, and, retaining the character of undifferentiated germ cells, are able to rejuvenate successive generations—the familiar "germ-plasm theory" commonly accredited to Wiesmann, but which Dr. Minot traces to Nussbaum. A new point of fundamental interest is raised in this connection, viz., the differentiation of nuclei; but while this is claimed we are disappointed that neither the figures nor the text makes it at all clear in exactly what changes this differentiation consists.

The final lecture on "The Four Laws of Age" gives the author's conclusion of the whole matter in categorical form.

First, rejuvenation depends on the increase of the nuclei.

Second, senescence depends on the increase of the protoplasm, and on the differentiation of the cells.

Third, the rate of growth depends on the degree of senescence.

Fourth, senescence is at its maximum in the very young stages, and the rate of senescence diminishes with age.

As the corollary from these, we have this—natural death is the consequence of cellular differentiation.

Those interested in education will find in this last chapter a fine statement of rapid mental growth of the infant.

Clearly in ultimate analysis the growth of an organism is but a small factor in the problem of its entire life. At a guess, the energy expended in growth is to the entire energy output of the organism as one to one thousand. It should also be remembered in this connection that all the material which enables the embryo to grow so fast at first is a function of the adult life work of the parents. An adult hen may lay 200 eggs in a single year, the materials of which may enable 200 chicks to complete 98 per cent. of their growth at hatching.

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The Development of the Chick: An Introduction to Embryology. By FRANK R. LILLIE. Pp. xi + 472. 251 Figs. New York, Henry Holt and Company. 1908.

The intention of the author of this book is to present in a simple, straightforward way the essential facts of the development of the chick for the use of beginners in embryology. This purpose has been to a very large degree realized, despite the ever-present temptation to enter into comparative discussions.

The book is divided into two sections, the first of which is devoted to a description of the formation of the embryo and is to an exceptional degree original and excellent. The second part, consisting of eight chapters on the development of the organ systems from the beginning of the fourth day of incubation to hatching, occupies a little more than half of the work.

The introduction is a statement of certain embryological theories and facts of general interest which can not properly be included in the body of the book.

The first chapter is a description of the structure, chemical composition and formation of the egg.

So little is known of the processes which occur while the hen's egg is in the oviduct that a consistent account of them is impossible. Consequently, Dr. Lillie in the second chapter bases the description of the development before laying, which includes the fertilization, maturation and cleavage of the ovum, and the formation of the ectoderm and entoderm, upon the work of Harper, Patterson and Blount upon the egg of the pigeon. This is an unavoidable exception to the author's rule of limiting the description to the development of the chick.

The third chapter contains a variety of material such as an outline of development, a statement of the orientation of the embryo in the egg, a discussion of the methods of classifying embryos, and an excellent table of the time of appearance and rate of differentiation of the organs. It would be wiser, perhaps, to omit this chapter because it makes too great a break in the account of the development of the embryo and contains much that the student can not yet understand. The content of the chapter could well be used elsewhere: for example, the section on orientation should be used, I believe, in connection with the account of the formation of the entoderm, given in the preceding chapter. The table, being merely for reference, should be used as an appendix.

The fourth chapter, entitled, From Laying to the Formation of the First Somite, is divided into four sections. The first is a description of the blastoderm in the unincubated egg and amounts to a review of the latter part of the second chapter. The primitive streak is described in the second section under four heads: Whole Views, Sections, The Head Process and Interpretation of the Primitive Streak. This division, especially the separation of the description of the whole views from that of the sections of the primitive streak, seems unwise. Four views of the blastoderm and three sections of the primitive streak of the sparrow, copied from Schauinsland, serve only to show by contrast the excel-